

**SCAR WORKSHOP ON BIOLOGY AND CONTAMINATION ISSUES:  
Meeting Report**

ROYAL ACADEMY, TRIPPENHUIS, AMSTERDAM,  
10:00-13:00, AUG 25 2001.

Convenors – J Cynan Ellis-Evans (BAS) and John Priscu (Montana State University)

**Agenda**

***Life in Subglacial Lakes***

The subglacial environment  
What do we know about the biota studied to date?  
What else could be there?  
General Discussion on Biology

***Contamination Issues***

Defining the problem  
Obtaining clean samples for analysis  
General Discussion on Contamination Issues

***AOB***

Information from the recent Canadian Workshop on subglacial lakes

**Life in Subglacial Lakes**

Cynan Ellis-Evans (CEE) opened the meeting with an outline of the state of current knowledge regarding the lakes and highlighted several new observations of relevance to the meeting.

- The Italian finding (by Tabacco et al (*Journal of Glaciology*, in press)) of a further 20+ lakes in the area of Dome C raising the total known to around 90 of which almost half occur under Dome C which has a very undulating bedrock landscape. The possibility exists of many of the lakes in this region being linked subglacially.
- The remarkably detailed geophysical survey of Lake Vostok by Robin Bell and Michael Studinger which has revealed a far more complex internal structure to this lake which will have substantial implications for lake circulation and therefore the chemistry and biology of Lake Vostok.
- Publication of models for circulation of water within Lake Vostok by Wuest & Carmack, Meyer and most recently Seigert et al (*Nature*, submitted) that suggest the likelihood of vertical density stratification and, as a result, the potential for more diverse chemistry and biology.
- The recent development of a model by Lipenkov & Istomin (*Glavatsiol. Issled.* **91**, in press) that predicts gas hydrates will be transferred from the basal ice to the lake water at the northern end of Lake Vostok and will remain intact within the water body. They further predict equilibrium with dissolved oxygen in the water which

could result in supersaturation of oxygen in the absence of any removal processes. As yet unreleased American research that includes a biological sink term for dissolved oxygen suggests hydrates will not be present in the lake.

- French measurements (Jean-Baptiste et al, *Nature* **411**, 460-462, 2001) of  $^3\text{He}/^4\text{He}$  ratios in accreted ice reveal low ratios which they consider indicative of there being little or no hydrothermal activity from high enthalpy mantle processes in Lake Vostok. It was pointed out that this assumes a well mixed lake. The circulation model of Siegert et al predicts that the lake will be stratified. If accreted ice originates from recently melted surface waters, then there would be no obvious hydrothermal signal in this ice.

**It was also pointed out that there is a growing belief that Lake Vostok, at least, originated around 15 million years ago, soon after the first permanent glaciation of Antarctica occurred. The possibility that a large water body existed at the site pre-glaciation raises the possibility that much older sediments, that escaped glacial scouring, might be present beneath the existing lake sediments. This again has considerable relevance for life in this lake.**

John Priscu outlined the current knowledge of biota in the overlying glacial and accreted ice. The early Abyzov data for glacial ice was outlined and contrasted with the latest findings using more rigorous procedures for ensuring clean samples. These new results indicate far lower cell numbers in glacial ice and very low DOC values. Curious alumino-silicate rods (mm's long) have been seen in ice samples examined by several labs. Most cells are coccoid rather than rods. Eukaryotes were not seen but two nematodes were observed (1 in accreted ice) and numerous diatom cell wall fragments were present. Virus particles have been detected in glacial ice but the observation is yet to be confirmed. Preliminary evidence indicates that microbial activity in melted glacial ice is low or absent.

Existing data on accreted ice indicates higher cell counts and higher DOC values than in glacial ice, which would imply the lake is active biologically and that glacial ice is not a major source of microbes to the lake. DOC in the lake may have largely derived from the very large catchment of Lake Vostok but this contention awaits confirmation.

JP outlined existing data on lake ice and water body communities of the McMurdo Dry Valley lakes, indicating the diversity of organisms present at 1-2 m depth in the ice and the community structure present. These and the communities of the water column and sediments beneath lake ice cover are ultimately driven and maintained by photosynthetic production and subsequent release of DOC. This DOC source is not directly available to subglacial environments. Glacial ice communities are apparently frozen solid and have to survive 500,000 to 1,000,000 years in this state before entering the lake. Evidence from permafrost suggests that only prokaryotes would survive this time scale. CEE proposed that a more likely source of microbes to Lake Vostok would be from the catchment bedrock and illustrated the potential for this with reference to recent work on microbes of the deep subsurface and from beneath modern glaciers. A wide range of chemoautotrophic and chemoheterotrophic microbes have been isolated from several

kilometers below the Earth's surface. Similarly a wide range of physiological groupings of microbes can be isolated from beneath glaciers.

A general discussion followed that particularly focused on gas hydrates which are critical to our understanding of both lake chemistry and biology. The Lipenkov & Istomin paper predicts hydrates remaining intact within the lake and in the view of Heinz Miller would imply that the lake eventually fills with gas hydrates. JP has observed hydrates in accreted ice suggesting a presence in the lake but an as yet unreleased American model is suggesting that hydrates do not persist in the lake. There is clearly a need to establish a gas balance for the lake. The Lipenkov & Istomin model does not consider biological consumption of dissolved oxygen or the potential for direct use of hydrate gas by microbes. There will clearly be an equilibrium between oxygen within hydrate crystals and dissolved in lake water. Recent circulation models suggest meltwater may not mix effectively with the main water body. This would infer a poor distribution of oxygen within the lake and thus the likelihood of a stratified lake in terms of oxygen. With the poor diffusion of gases through sediments it can be anticipated that limiting oxygen will result in anoxic sediments.

### **Contamination Issues**

To start off the consideration of contamination issues CEE put up a definition of contamination, which recognizes that naturally occurring environmental microbes, as well as human sourced microbes, and chemicals must be included. The impact of potential biological and chemical contamination was outlined from the dogmatic view of pristine status maintenance vs. a more pragmatic approach (as seen in Planetary Protection). Three different views for considering subglacial research were also proposed.

- All subglacial lakes are precious
- Lake Vostok is precious and other subglacial lakes less so
- Strictly limited contamination of any lake is acceptable

The first option implies totally contamination-free sampling, which may be impracticable, and may mean leaving all the lakes untouched. The second option is the view of some scientists and much of the general public as a result of media coverage but is based on a heavily skewed data set with virtually negligible data coverage for the smaller lakes. The third option takes a pragmatic stance comparable to that taken by NASA for planetary protection and assumes substantial dilution effects but would necessitate overcoming existing public concerns regarding contamination.

JP then presented an outline of how his group undertakes clean sampling of existing Vostok ice cores to illustrate the scale of cleanliness required. Class 100 laminar flow benches in Class 100 rooms with all attendant clean room protocols are followed and to obtain clean melt water ~30% of the core volume is sacrificed. Similarly around 20% of the ice volume is sacrificed to obtain clean melt water for DOC analyses. There is evidence that simply doing sequential washes with deionised water are not as effective as initial wash followed by slow melt in sterile air to obtain reliably clean material. Cell counts showed low numbers after the first wash, but a further substantial reduction in cell counts with the subsequent melt in sterile air. The third melt yielded a much smaller

decrease in numbers suggesting that counts were now close to background. Evidence of bacteria was seen in both visual inspections and in molecular profiles.

Sergey Bulat (SB) proposed that virtually all commercially available high purity water had a DOC background in the low ppb range, a fact which needs to be recognized when preparing clean ice samples using high purity water washes. SB also reported his group's molecular studies on glacial and accreted ice and stated that they found no microbes in the deep glacial ice and virtually nothing in the accreted ice so contradicting earlier studies by Abyzov (*Antarctic Microbiology*, 265-295, 1993), Priscu et al (*Science*, **286**, 1999) and Karl et al (*Science*, **286**, 1999). It was further proposed that DNA would degenerate over the timescale needed to pass through 4 km of glacial ice. Some unidentified DNA was observed on occasion that could not be attributed to existing DNA profile databases.

There is clearly a need for cross-checking between labs and to this end it was subsequently proposed that JP and SB exchange samples for comparison of techniques. It was also pointed out in discussion that the volume of material available for ice analyses is so limited that the possibility of erroneous results becomes significant and the representativeness of such a small sample size also becomes important. Large amounts of Vostok ice core are still stored at the Vostok station and it was suggested that perhaps more ice samples could be made available.

Two examples of lake penetration technology were presented to illustrate just some of the proposals currently in existence and as a basis for considering possible contamination issues. Erik Blake (Canada) presented a hybrid hot water drilling/Phillbert probe design that penetrates the ice sheet, enters the lake water body to measure various physical/chemical parameters and obtain water samples and then cores the lake sediments. CEE outlined a recent proposal from Russia that utilizes the existing drill hole that ended 150 m above the lake, rather than drilling a costly new 4000 m hole (see Russia research page on the SALE Website). The Russian proposal envisages replacing the kerosene/freon drilling fluid at the bottom of the hole with a sterile filtered hydrophobic organosilicone fluid. Electro-mechanical drilling and then thermal drilling would be employed to reach the ice/water interface. The hole would then be sealed with a valve and pressure adjusted (by pumping) with the lake so that on withdrawing the thermal drill, lake water flooded up into the hole, froze as a column of ice within the drill hole and could then be sampled using the electromechanical drill.

Both prototype systems had their merits but also came in for some criticism on technical grounds. Useful pointers were provided to EB on more clearly establishing the likely pressure regime during the stages of the penetration process. The proposed deployment plan to combine parameter measurements, water sampling and coring in the one penetration process was regarded as potentially over-ambitious and further exacerbating the issue of contamination. Undertaking the coring in a separate penetration was seen as more realistic. The current design was seen as complicated to decontaminate effectively and CEE presented the existing list of cleaning procedures used by NASA for planetary protection purposes and suggested that none of these methods could individually clean

the Canadian system reliably. A combination of cleaning procedures was considered a more effective strategy but this will need further consideration.

There were doubts voiced regarding the benefits of essentially obtaining only more accreted ice by the Russian methodology. There was greater interest in penetrating and working within the lake itself, particularly the sediments. The effectiveness of the proposed cleaning strategies were unproven and the likelihood of obtaining clean samples was therefore questioned. Ricardo Roura voiced the view of the ASOC environmental lobby that the Russian proposal be fully examined by the international community before proceeding with field work. In response it was pointed out that an internationally approved Comprehensive Environmental Evaluation will be necessary before any lake penetration occurs.

It was noted that there is a dearth of knowledge regarding the movement of drilling fluids through accreted ice. The Russian proposal to drill a further 50 m through accreted ice this coming season (2001-02) was acknowledged to be raising concerns and would have to be discussed further at the SALE GoS meeting in Bologna (September 2001). Karl Erb (USA) asked for clarification regarding the long-term fate of the drilling fluid within the existing Vostok drilling hole, given that the ice was moving across the lake and downwards to the ice/water interface. There is a limited amount of information available regarding containment of the fluid within the drill hole by surrounding accreted ice. It was accepted that any diffusion process was likely to be happening very slowly and that simultaneously the lake water was accreting to the base of the ice sheet at around 4mm per year. The Vostok drill site is located towards the western edge of the lake and accreted ice is currently thought to be carried with the glacial ice across the lake and over the western shore so the threat to the water body was probably minimal. However the presence of over 60 tons of drill fluid in the existing hole was not felt to be an appropriate situation long-term and that the Vostok drilling group should be considering means to remove this and similar environmental contamination in the area in due course.

#### **AOB**

Warwick Vincent briefly reported on the workshop held earlier this year in Canada on the possible Canadian role in subglacial research. This concluded that Canada would for now place its emphasis on developing research initiatives in subglacial analogues present in arctic Canada – e.g. Ward-Hunt ice shelf. It was pointed out that there were opportunities for international collaboration with this work in future.

Cynan Ellis-Evans  
2 Sept 2001

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